International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 9, Issue 4, Aug 2019, 1173-1182

DESIGN AND ANALYSIS OF PARALLEL FLOW HEAT EXCHANGER WITH BAFFLES

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ABSTRACT

Shell and tube heat exchanger is the most common type of heat exchanger, widely used in oil refinery and other large chemical process. The energy present in the exit stream of many energy conversion devices such as I. C engines, Gas turbines etc. goes as waste, if not utilized properly. For example, the heat energy stored in the engine coolant can be utilized in a better way by recovering the heat for heating purposes inside the cabin. It is comparatively economical than the existing heating arrangements, which employ conventional heating coils. So, the present work has been carried out with a view to predicting the performance of a shell and tube heat exchanger in the field of waste heat recovery application. The objective of this project is to design a shell and tube heat exchanger and study the flow and temperature field inside the shell and tubes using ANSYS Fluent R14.5. An attempt has been made to calculate the performance of the above heat exchanger with and without baffles for parallel flow configurations, and the results so obtained have been compared.

KEYWORDS: Shell and Tube Heat Exchanger, With and Without Baffles Design & Flow Analysis

Received: May 16, 2019; **Accepted:** Jun 03, 2019; **Published:** Jul 22, 2019; **Paper Id.:** IJMPERDAUG2019122

Original Article

INTRODUCTION

This paper study the heat exchanger without modified design and with modified design finally correlated the exist things [1]. It presents the design and analysis of heat exchange with pphe model, and analyse the exiting performance [2]. The heat exchange is designed and analysed using entancy technology. In this technology, the heat exchange has improved the performance of 32%[3]. The aim of the work is optimization of the heat exchanger plate. In this, optimization improves the performance of 20%[4], the heat exchanger shell plate is removed alternatively and the pins are inserted to study the performance[5]. The cascade technology heat exchangers are used, in this, heat exchanger improves the input air standard, and hence the efficiency of heat exchanger is improved[6]. A coupled heat transfer and tritium mass transport model was developed for performance analysis of a double-wall Natural Draft Heat Exchanger (NDHX) design [7]. The high energy heat exchanger is used in a passenger vehicle. In this, heat exchanger improves the vehicle's efficiency [8]. The work improved the heat exchanger's performance under fowling valves. If the valves are inserted in heat

exchanger, the efficiency of heat exchanger can be improved [9]. The sensitive type of heat exchanger is used. The heat exchanger modifies model PHN. In this modification, the performance of heat exchanger can be improved [10].

DESIGN OF HEAT EXCHANGER

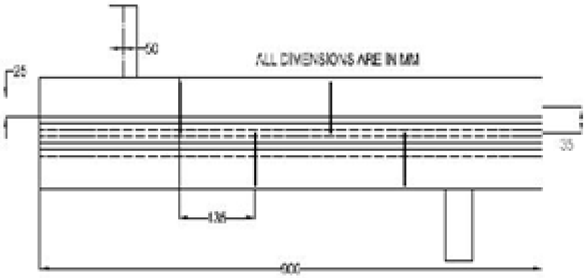

Figure 1: 2D Drawing of the Heat Exchanger without Baffles {1}

The Figure 1 shows the heat exchanger 2D model diagram. The diagram shows the dimension of the heat exchanger (figure 1)

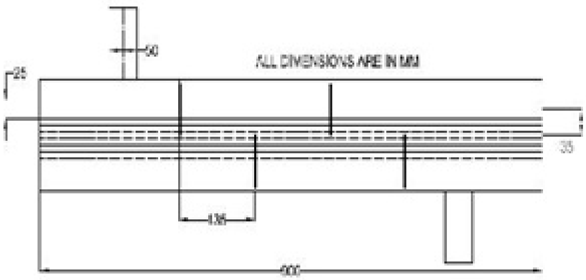

Figure 2: 2D Drawing of the Heat Exchanger with Baffles

The Figure 2 shows the heat exchanger 2D model diagram {2}. The diagram shows the dimension of the heat exchanger and modifies the baffles dimension (figure 2)

2D Drawing of the Heat Exchanger with Baffles (Simplified)

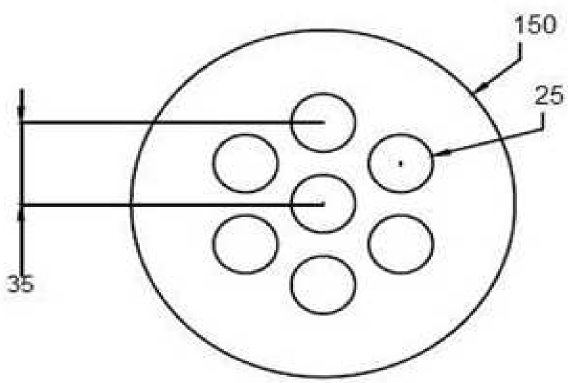

Figure 3: 2D Drawing of the Heat Exchanger Cross Section View {1}

The Figure 3: shows the heat exchanger cross section view of model diagram. The diagram shows the dimension of the heat exchanger in a cross section view (figure 3)

TUBESHEET WITH TRIANGULAR ARRANGEMENT

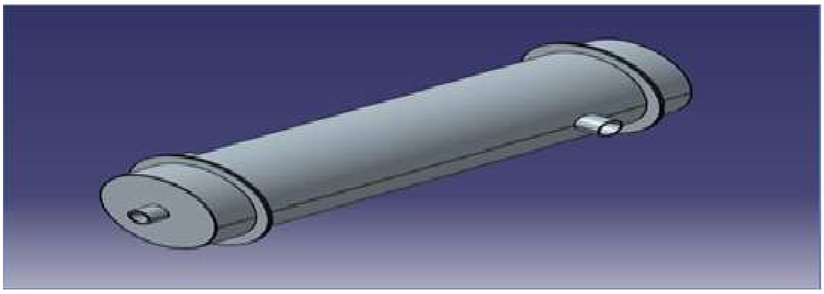

Figure 4: 3D Model of Heat Exchanger

The Figure 4 shows the heat exchanger 3D model diagram. The diagram shows the Proto type of the 3D model heat exchanger[10] (figure 4)

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Table 1: Dimensional Details of Shell and Tube Heat Exchanger

	Diameter	150mm
SHELL	**Length**	900mm
	Working fluid	Water @ 450K
	Material	Mild steel
	Diameter	1” ≈ 25mm
	Length	900mm
TUBE	**Working fluid**	Air @ 300K
	No. of tubes	7
	Material	Aluminium
	Tube arrangement	Triangular
	Diameter	140mm
	Material	Aluminium
BAFFLES	**No of baffles**	4
	Baffle pitch (spacing)	135mm
	Baffle type	Segmental

DESIGN CALCULATIONS

The dimensions of the shell and tube heat exchanger are as follows[8]:

Tube diameter: 25mm

Shell diameter: 150mm

Tube length: 900mm

Velocity of air: 5 m/s

Velocity of hot water: 1 m/s

Parallel Flow

UnBaffled

Inlet water temp (T1): 450K = 177°C

Outlet water temp (T2): 449.934 K = 176.934°C

Inlet air temp (t1) = 300K

Outlet air temp (t2) = 376.928 K

We know that,

Heat given up by the hot fluid (Qh) = mh Cph (T1 – T2)

mh = ρ A v

=889 × 3.433 × 10-3 × 1

=3.0522 kg/s

Qh = 3.0522 × 4417 × (450 – 449.934)

Qh = 889.706 W

Heat gained by the cold fluid (Qc) = mc Cpc (t1 – t2)

mc = ρ A v

=1.045 × 1.963 × 10-3 × 5

=0.010256 kg/s

Qc = 0.010256 × 1007 × (376.928 – 300)

Qc = 704.496 W

Baffled

T1 = 450 K

T2 = 449.9208 K

t1 = 300 K

t = 392.562 K

Heat given up by the hot fluid (Qh) = mh Ch (T1 – T2)

mh = 3.0522 kg/s

Qh = 3.0522 × 4417 × (450 – 449.9208)

Qh = 1067.74 W

Heat gained by the cold fluid (Qc) = mc Cpc (t1 – t2)

mc = 0.010256 kg/s

Qc = 0.010256 × 1007 × (392.562 – 300)

Qc = 955.96 W

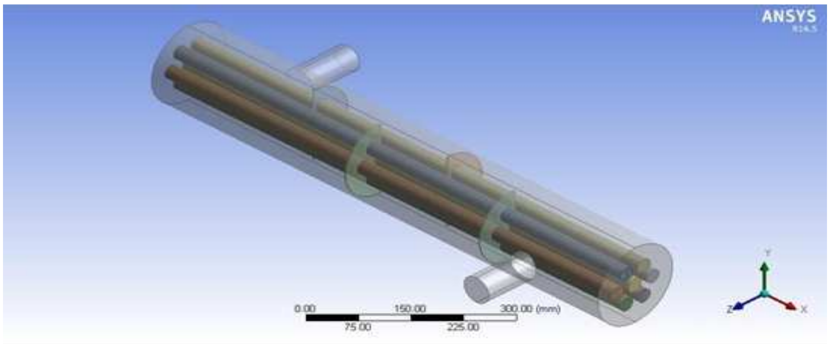

Figure 5: 3D Model of Heat Exchanger with Baffles[5]

The Figure 5: shows the heat exchanger 3D model diagram. The diagram shows the Cut Section Model of the heat exchanger With Baffles Design (figure 5)

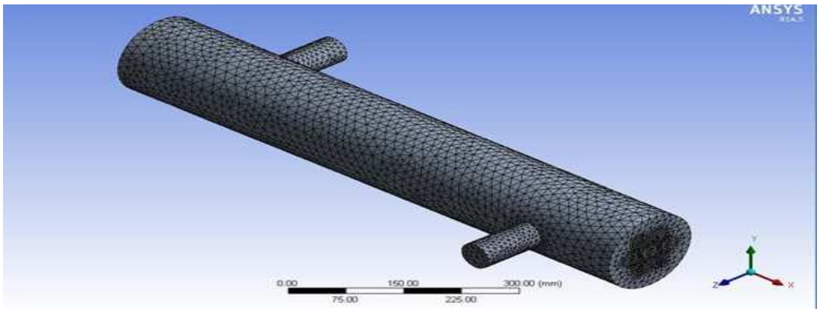

Figure 6: Meshed Geometry Containing Triangular and Quad Type Mesh[9]

The Figure 6: shows the heat exchanger 3D Meshing. The diagram shows the Tetrahedral mesh Model of the heat exchanger With Baffles Design (figure 6), the meshing purpose to discrete the elements

MESHING DETAIL[11]

Mesh type: Tetrahedral

Moving mesh: Boundary velocity 120 m/s

Mesh quality check:

Aspect ratio: 0.5

Density: 5

War page angle: 0.2

Skew angle: 0.4

BOUNDARY CONDITION

Table 2: Boundary Condition of Shell and Tube Heat Exchanger

Boundary Conditions	Details	
SHELL (AIR)	Temperature	300K
	Velocity at Inlet	5 m/s
TUBE (WATER)	Temperature	450K
	Velocity at Inlet	1 m/s
BAFFLE	Specified as wall	

PARALLEL FLOW

Pressure Contours [10]

Without Baffles

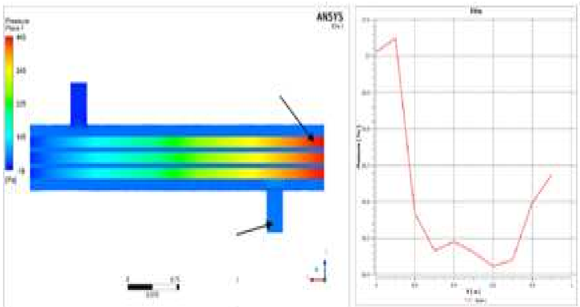

Figure 7: Without Baffles

The Figure 7 shows the heat exchanger 2D analysis Results. The Results show that the analysis result in pressure contours of the heat exchanger, without baffles design (figure 7)

With Baffles

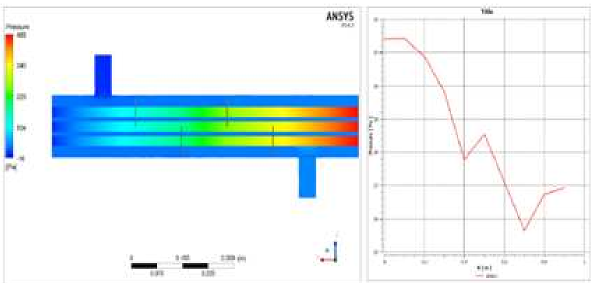

Figure 8: With Baffles

The Figure 8 shows the heat exchanger 2D analysis results. The results show the analysis Result Pressure Contours of the heat exchanger, Without Baffles Design (figure 8). The pressure distribution with and without baffles in a heat exchanger are shown in the image. The maximum pressure obtained in a 'without baffles' is 0.15m and with baffles 0.3m, and the pressure with 50 % improvement. [13]

Velocity Contours

Without Baffles

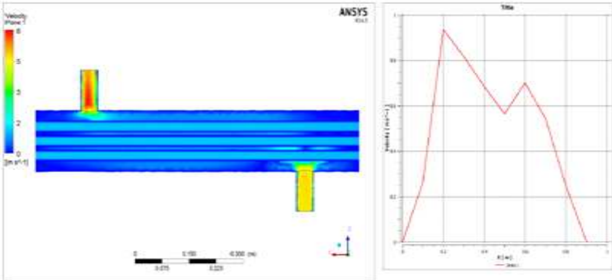

Figure 9: Without Baffles

The Figure 9 shows the heat exchanger 2D analysis results. The results show the analysis Result Velocity Contours of the heat exchanger, Without Baffles Design (figure 8)

With Baffles

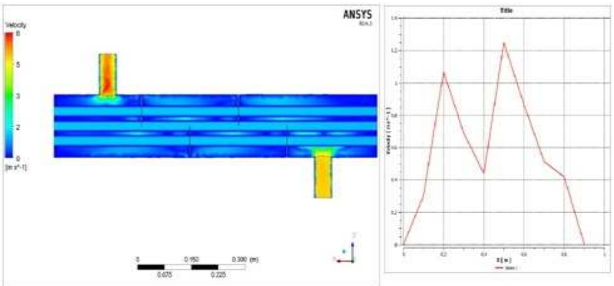

Figure 10: With Baffles

The Figure 10 shows the heat exchanger 2D analysis results. The results show the analysis Result Pressure Contours of the heat exchanger, With Baffles Design (figure 10). The velocity distribution with and without baffles in a heat exchanger is shown in an image. The maximum pressure obtained in a without baffles is 0.300m and with baffles 0.300m. The velocity has no improvement[11].

Temperature Contours

Without Baffles

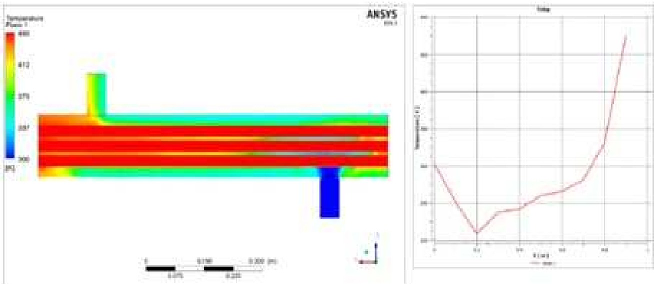

Figure 11: Without Baffles

The Figure 11 shows the heat exchanger 2D analysis results. The results show the analysis Result Temperature Contours of the heat exchanger, Without Baffles Design (figure 11).

With Baffles

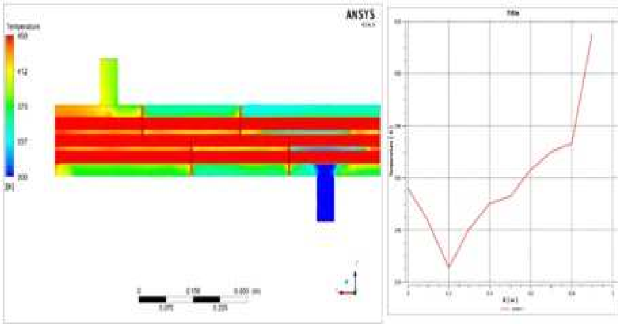

Figure 12: With Baffles

The Figure 12 shows the heat exchanger 2D analysis results. The results show the analysis Result Temperature Contours of the heat exchanger, With Baffles Design (figure 12). The temp distribution with and without baffles in a heat exchanger is shown in an image. The maximum pressure obtained in a without baffles is 400k and with baffles 405. The temperature has a5% improvement

RESULTS & DISCUSSIONS

Table 3: Result of Parallel Flow Heat Exchanger

Type of Flow	Configuration	Shell Inlet Temperature	Shell Outlet Temperature	Total Heat Transfer Rate (Tube Wall)
Parallel flow	Without baffles	300 K	376.92 K	912.26 W
	With Baffles	300 K	392.56 K	1034.95 W

The total heat distribution with and without baffles in a heat exchanger is shown in table 3. The maximum temperature obtained in a without baffles is 912.26W and with baffles 1034W. The temp has a 10% improvement. And, the heat exchanger will be analyzed for counter flow in future.

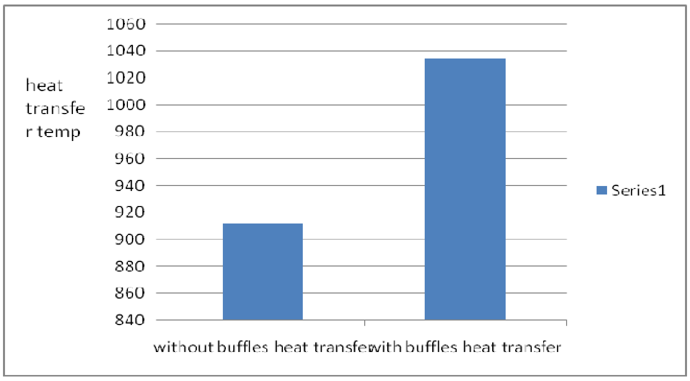

Figure 12: Compression Chart with & without Baffles Heat Exchanger - Heat Transfer Temperature

The figure 12 is the compression chart, which shows the without and with baffles heat exchanger results. The results were derived from Ansys Flow Simulation. The result shows the heat transfer rate of without heat exchanger as 912 W and with heat exchanger as 1035 W. The improvement has modified the heat exchanger design. The net improvement of the heat exchanger with baffles temperature output is 13%.

CONCLUSIONS

CFD analysis has been carried out on shell and tube heat exchanger; one with baffles and another without baffles. The various parameters such as pressure, temperature and velocity distribution throughout the shell and tube heat exchanger has been determined, and its results were compared. It is found that the Parallel flow heat exchanger with baffles shows the highest heat transfer capability, but it has more pressure drop when compared to the heat exchanger without baffles. And in the baffles heat exchanger, the maximum shown in outlet temperature is 392.56K. And the total heat transfer rate in a tube wall is at 1034.95 W, compared to the normal heat exchanger. In the present work, the pressure and temperature have shown improvement. But, the velocity remains the same. In the Engineering applications, in a heat exchanger, the heat improvement is the most important work. So, the above design model will give improvement in pressure and temperature, and neat heat output. So, in a similar work as a future study, we will do the counter of flow heat exchanger.

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